A Forward Silicon Strip System for the ATLAS HL-LHC Upgrade

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- The ATLAS Endcap HL-LHC Upgrade
- The Petalet Project
- Freiburg Hybrid Specification and Population
- Hybrid Test Results
- Module Building
- Summary / Outlook

ATLAS Endcap HL-LHC Upgrade

- Inner Tracker (IT) needs upgrade for HL-LHC
 - Radiation damage of IT
 - HL-LHC track density too high for current IT granularity
- New barrel integration concept: readout electronics glued directly on sensor, sensor glued to support structure
- New IT will have:
 - p-type sensors
 - 5 barrel layers
 - 6 endcap disks:
 - Each disk has 32 “petals” (close to barrel stave design)
 - Each petal has 2x9 sensors

See also the talk “Upgrading the ATLAS Silicon Tracking of the HL-LHC” from Tom Barber

The Petalet Project

- Build small petal, the petalet, to concentrate on major subjects: innermost radius with smallest strip pitch and region where petal splits in 2 sensor columns
- Sensors are build at CNM

drawing of the petalet core

CNM Sensors for Petalet I

- Design and production for 4" wafer
 - Different strip pitch
 - Implemented stereo angle (20mrad)
 - Double metal layer to implement embedded fanins which match with the bondpads of the readout chips to avoid large bond angles
- First run without embedded fanins shipped begin of May
- First run with double metal mini sensors show differences to single metal layer → under investigation

CNM Sensors for Petalet II

- Depletion Voltage:
70V - 95V

- CV and IV measurements of all sensors in Freiburg (for 2 full petalets)
 - Results show good agreement with measurements from CNM

Two Petalet Versions

■ “The Bear”:

- Power and Data on two different sides/bus cables
- One single hybrid for top sensors

■ “Lamb and Flag”

- Data and power on same side of bus cable
- Each sensor has its own hybrid

Petalet Bus Cable

“Bear”

“Lamb and Flag”

First design studies of the bus cable for both petalet versions shown were done

- Lamb and Flag: not so much space on the bus cable so that the DCDC converter is overhanging

Freiburg Hybrid

- Hybrid for “big” petalet sensor (Bear) produced
 - Design at Freiburg
 - 4-Layer Flex-PCB (85mm x 28mm)
 - 100μm track and gap
 - Production and population of **Surface Mounted Devices** (resistors, capacitors) by German companies
 - Received first batch begin of July this year

ASIC to Hybrid glueing

- Use same method as for stave module building:
 - ASICs placed in Chip Tray and picked up with Pickup Tool
 - Silver epoxy glue spread on backside of ASICs with ASIC Glue Stencil
 - ASICs glued on hybrid (placed on jig) with Pickup Tool
 - Glue height is defined with fine thread screws on Pickup Tool

Complete Hybrid

Planned glue height
approximately $60\mu\text{m}$

- Glue dots compressed and no glue oozes out
- Measurements show good agreement

Hybrid Test Results

Gain

Noise

Test results of petalet hybrids (80MHz readout with HSIO) are comparable with hybrids of the stave programme (~400 Equivalent Noise Charge $\approx$ electrons)

Module Building

- Sensor placed on Module Building Jig
- Use Pickup Tool to lift hybrid
- Glue spread on backside of hybrid with metal Hybrid Glue Stencil
- Hybrid glued on sensor
 - Normal bond pads and embedded fanins have different radial locations, 2 alternative positions provided by brass inserts
- Glue height defined by jig design (height difference between sensor backside and fine thread screws)

Module Building Jig

brass inserts

Hybrid Glue Stencil

glue on hybrid backside

Petalet Big Sensor Module

Planned glue height
between 100 μ m and
120 μ m

- Measurements show
good agreement

- First module test: good tested
hybrid glued on glass sensor
dummy with bondpads
 - No change in performance
- Initial test planned with B-grade
sensor (upper picture)

Summary / Outlook

- Single metal layer sensors produced, shipped and ready for usage, batch of sensors with two metal layers in production
- Hybrids for big sensor (“Bear” version) designed and produced
 - Performance tests of single hybrids excellent (Noise ~ 380 ENC), tests for first module started
- Construction of top hybrid for “Bear” petalet started → planned completion date: early December
- Design of tools for new hybrid nearly finished, will start production soon
- Design of hybrids for “Lamb and Flag” version and the bus cable started
- Design of core nearly finished, will start construction with support from LBNL

Thank you for your attention.

Backup

Petalet Sensors / Wafer

- Wafer with petalet sensors, produced by CNM

CNM IV Measurements

CNM CV Measurements

6214 Pad

Depletion ~ 70 V

6215 Pad

HSIO Readout System

HV power supply

LV power supply

HSIO power supply

readout board power supply

- Test device in light tight box, flushed with nitrogen and mounted on a cooled test jig (8°C)
- HSIO: High Speed I/O with good Virtex FPGA

thermistor measures temperature on hybrid

HSIO board

light tight box with test device

Hybrid/Module Testing

Test hybrids with selfmade testframe

Top Sensor – Bear Module Building

- Design of tools for top sensors (“Bear” version)
 - Sensors will be connected by one large hybrid